

## FREE FLIGHT PROGRAM UPDATE

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### **Abstract**

In close collaboration with the aviation industry, the Federal Aviation Administration's (FAA's) Free Flight program is fielding several advanced Air Traffic Management (ATM) automation systems and evaluating their ability to provide economic benefit to airspace system users. The paper describes the Free Flight Phase 1 (FFP1) program, which ran from 1998 to 2002 and fielded five automation systems. A summary of user benefits resulting from the deployment of these five tools is presented, both qualitatively and quantitatively. Based on the success of FFP1, the FAA is now undertaking a follow-on program, Free Flight Phase 2 (FFP2). This initiative is expanding the deployment of the User Request Evaluation Tool (URET) and Traffic Management Advisor (TMA), is continuing the development of Collaborative Decision Making (CDM), is introducing an aeronautical data link, and is facilitating several new research programs. The paper describes these efforts and presents the current deployment schedules.

### **Introduction**

Since 1998 the Free Flight program has been fielding advanced Air Traffic Management (ATM) automation systems throughout the United States in order to help controllers and airline professionals better perform their jobs, and in this way improve the capacity and efficiency of the National Airspace System (NAS). Based on the success of Free Flight Phase 1 (FFP1), as demonstrated by several years of operational experience and numerous operational evaluations, the Federal Aviation Administration (FAA) has approved the Free Flight Phase 2 (FFP2) program, which will continue the deployment of FFP1 systems, and develop and demonstrate new ATM capabilities.

This paper will review the history of the FFP1 program and summarize the results to date of the assessments of the program's impacts on airspace system users and controllers. The current plans for FFP2 will also be described.

### **Free Flight Phase 1**

FFP1 was established in October 1998 by then FAA Administrator Jane Garvey to field and evaluate five new ATM capabilities:

- User Request Evaluation Tool (URET)
- Traffic Management Advisor (TMA)

- passive Final Approach Spacing Tool (pFAST)
- Collaborative Decision Making (CDM)
- Surface Management Advisor (SMA)

These capabilities had been defined by the RTCA<sup>1</sup> through a consensus process that drew upon the airline industry, labor organizations, the NAS Modernization Task Force, and other FAA offices.

While fielding these capabilities, the Free Flight Program Office has focused on achieving these RTCA-recommended goals:

- Achieve early benefits by deploying low-risk technology while maintaining or exceeding current levels of safety
- Provide operational availability and evaluate performance of the core capabilities by the end of calendar year 2002
- Extend early benefits to NAS users and service providers
- Employ an evolutionary development paradigm
- Make leveraged use of proven technologies.

To a large extent these goals have been achieved, with four of the five planned capabilities now operational throughout the NAS.

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<sup>1</sup> RTCA, Inc. is a private, non-profit corporation that serves in an advisory role to the FAA, developing consensus-based recommendations on air traffic control system issues.

## User Request Evaluation Tool

### System Description

URET assists air traffic controllers with the detection and resolution of aircraft-to-aircraft and aircraft-to-airspace separation problems. In this way it helps the NAS support a greater number of user-preferred flight paths, and allows increased system capacity while maintaining the current level of safety. The key currently fielded URET capabilities include:

- Trajectory modeling
- Aircraft and airspace conflict detection
- Trial planning to support conflict resolution of user or controller requests, and
- Electronic flight data management.

URET processes real-time flight plan and track data from the Host computer system. These data are combined with local airspace definitions, aircraft performance characteristics, and winds and temperatures from the National Weather Service to build four-dimensional flight trajectories for all flights within or inbound to the facility's airspace. URET also provides a "reconformance" function that continuously adapts each trajectory to the observed position, speed, climb rate, and descent rate of the modeled flight.

URET maintains "current plan" trajectories (i.e., those that represent the current set of flight plans in the system) and uses them to continuously check for aircraft and airspace conflicts. When a conflict is detected, URET determines which sector to notify and displays an alert to that sector up to 20 minutes in advance. Trial planning allows a controller to check a desired flight plan amendment for potential conflicts before a clearance is issued. The controller can then send the trial plan to the Host as a flight plan amendment. Neighboring URET systems will exchange flight data, position, reconformance data, and status information in order to more accurately model trajectories. For more details about URET capabilities, refer to Reference 1.

URET was originally deployed as a prototype system at two en route Centers in FFP1 (Indianapolis and Memphis). Following a successful evaluation, a production version (referred to as "Core Capability Limited Deployment") was deployed at five additional Centers, as well as at the two original Centers, between December 2001 and April 2002. Figure 1 depicts the current (and complete) FFP1 URET deployment.<sup>2</sup>

<sup>2</sup> Because of a shortfall in training funds, at the time of writing URET was not yet being used by controllers at Atlanta Center.

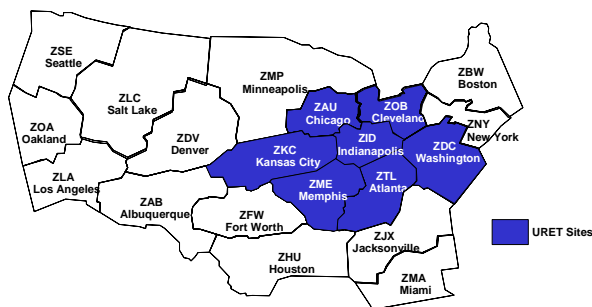


Figure 1. FFP1 URET Sites

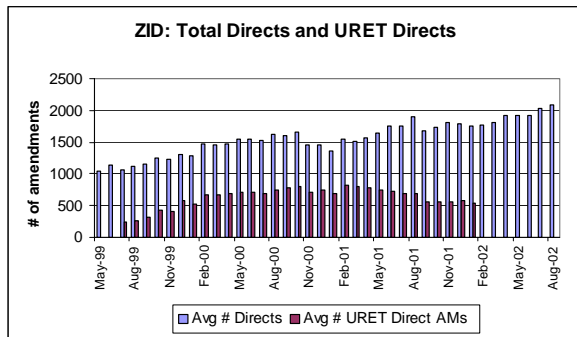
### User Benefits

The benefits accruing to airspace system users from URET include more efficient routings and vertical flight profiles. The metrics that have typically been used to quantify these benefits are:

- Fuel savings from removal of static altitude restrictions
- Number of direct flight plan amendments
- Distance saved from lateral flight plan amendments
- Flight times/distances for representative city pairs.

Previous studies have identified many altitude restrictions that have been removed as a result of URET usage at Indianapolis and Memphis Centers. Reference 2 reported on five restrictions that have been removed at Memphis, and 25 that have been removed at Indianapolis. An analysis of 10 of these restrictions at Indianapolis Center (ZID) found that airspace users are saving about \$950,000 per annum as a result of their removal.

URET use has been gauged by the number of flight plan amendments entered using the tool. Figure 2 shows the total number of direct amendments and the number of URET-initiated direct amendments at ZID from May 1999 through August 2002, using the prototype system. The figure demonstrates that there was a significant increase in flight plan amendments resulting in direct routings since July 1999, when the URET capability was extended to allow amendments to be sent directly to the Host computer. Similar results were found at Memphis Center (ZME) using the prototype. Note that MITRE's ability to count URET-initiated direct amendments ended with the installation of CCLD in January 2002. Likewise, MITRE's ability to count the total number of directs at ZME ended in March 2002, and in August 2002 at ZID. Recent results using CCLD data collection mechanisms indicate that there has been no appreciable reduction in the number of amendments relative to the prototype systems [3].



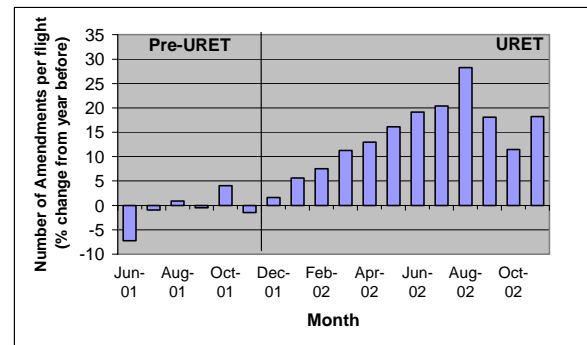
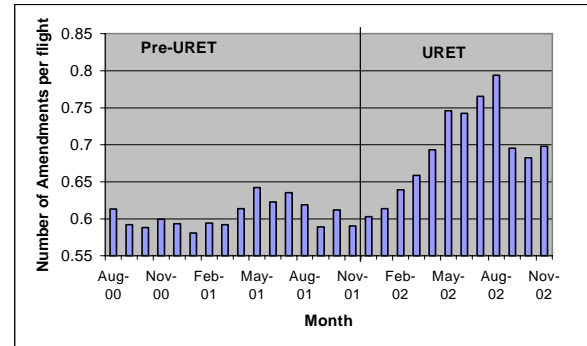
**Figure 2. URET Direct Amendments, ZID**

Enhanced Traffic Management System (ETMS) data has been used to calculate the total number of flight plan amendments in the new (i.e., CCLD) URET Centers. If URET were to increase the number of direct amendments (as it did at ZME and ZID), this should be reflected in the *total* amendments per flight. The top panel of Figure 3 shows the monthly average of the number of amendments per flight at Kansas City Center (ZKC) between August 2000 and November 2002. The vertical line designates the approximate date when URET became operational there. To the left of the line, aside from a seasonal effect, there is no obvious trend in the data. In order to account for the seasonal effect, the year-over-year change in the number of amendments per flight was computed and is shown in the bottom panel of Figure 3. In this figure we can see an increase in the number of amendments per flight after the introduction of URET. Similar results have been shown for the other new Centers [3].

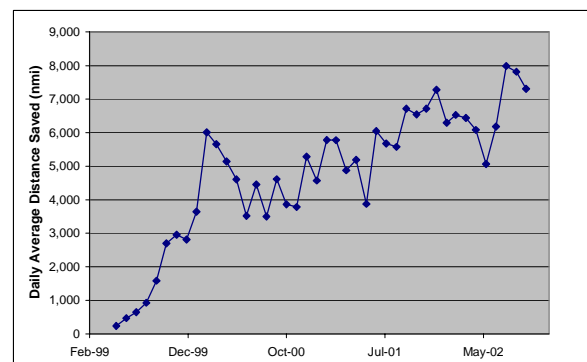
Figure 4 presents the total distance savings from lateral amendments for ZID (as monitored by the prototype) by month through October 2002. Distance savings from lateral amendments have increased from approximately 500 nmi daily (May and June 1999, before URET could send amendments to the Host) to more than 7,000 nmi through Fall 2002. Note that this metric should increase in the post-September 11<sup>th</sup> era, since, with fewer aircraft flying, there should be less congestion and consequently more direct routings. Software is under development to compute this metric for the new URET Centers using ETMS data.

Several analyses of average flight times and distances for flights which traverse URET airspace have been reported on in the past [4,5]. A recent analysis attempted to correct for varying wind speed on average en route flight times for selected city pairs [3]. This flight time wind-adjustment methodology was applied to data for the four new FFP1 Centers with the goal of assessing the impact of URET on

those sites. Actual flight times and flight distances were collected for flights between these city pairs for a number of sample days; typically, two to three weekdays per month were sampled for the period February 2001 through August 2002. Wind-adjusted flight times were averaged for all available days after Initial Daily Use (IDU) for each Center to arrive at a post-URET value for each city pair. For comparison, the previous year's data was also sampled for the same months.



**Figure 3. Flight Plan Amendments at ZKC**



**Figure 4. Distance Saved at ZID**

A comparison of average wind-adjusted flight times for pre- and post-URET periods is shown in Table 1. Both Cleveland (ZOB) and Chicago (ZAU) Centers consistently show decreases in wind-adjusted

times—for ZOB, all eight city pairs showed decreases, while for ZAU, 8 of 9 city pairs showed decreases. Averaged over all of the selected city pairs, ZOB and ZAU showed decreases of 1.4 and

0.6 minutes, respectively. There appeared to be no observable change in the wind-adjusted times for ZKC and Washington Center (ZDC).

**Table 1. Wind-Adjusted Flight Times, Actual Flight Times, and Flight Distances for Selected City Pairs**

Center	City Pair	Avg. Wind-Adjusted Flight Time (min)			Center	City Pair	Avg. Wind-Adjusted Flight Time (min)		
		Pre-URET	Post-URET	Change			Pre-URET	Post-URET	Change
ZOB	BOS to ORD	94.2	94.1	-0.1	ZDC	EWR to MCO	103.4	103.6	0.2
	ORD to BOS	94.7	92.5	-2.2		MCO to EWR	103.8	104.6	0.8
	JFK to LAX	272.9	269.4	-3.5		EWR to ATL	78.3	78.7	0.4
	LAX to JFK	274.7	270.4	-4.2		ATL to EWR	80.1	80.1	0.0
	PIT to ORD	40.7	40.7	-0.1		LGA to CLT	56.1	55.1	-1.0
	ORD to PIT	40.7	40.4	-0.2		CLT to LGA	57.7	56.7	-1.0
	PHL to ORD	74.6	74.1	-0.5		PHL to ATL	69.7	70.2	0.4
	ORD to PHL	73.0	72.7	-0.3		ATL to PHL	70.9	70.7	-0.2
	Average	120.7	119.3	-1.4		Average	77.5	77.5	0.0
ZAU	DTW to MSP	55.2	54.8	-0.4	ZKC	ATL to DEN	130.1	130.3	0.1
	MSP to DTW	54.8	54.6	-0.3		DEN to ATL	129.1	129.9	0.8
	ORD to MSP	38.8	38.9	0.1		ORD to DFW	86.6	87.1	0.5
	MSP to ORD	32.5	32.2	-0.2		DFW to ORD	86.2	86.1	-0.1
	ORD to DEN	93.7	92.9	-0.8		ORD to IAH	104.1	104.3	0.2
	DEN to ORD	97.1	96.0	-1.0		IAH to ORD	102.7	103.0	0.3
	ORD to LAX	190.4	189.6	-0.9		MCI to DFW	48.1	48.6	0.5
	LAX to ORD	193.5	192.1	-1.4		DFW to MCI	45.3	46.0	0.7
	DFW to ORD	86.6	86.2	-0.3		STL to PHX	142.8	141.2	-1.6
	Average	93.6	93.0	-0.6		PHX to STL	139.9	139.5	-0.4
						Average	101.5	101.6	0.1

Shaded cells indicate reductions in the various metrics/city pairs.

## Traffic Management Advisor

### System Description

The Center-TRACON Automation System (CTAS) consists of two major components: TMA and pFAST. During FFP1, TMA was installed (and is currently operational) at Ft. Worth, Minneapolis, Denver, Los Angeles, Atlanta, Miami, and Oakland Centers.

TMA assists controllers in the en route cruise and transition airspace. TMA provides Center personnel with a means of optimizing the arrival throughput of capacity-constrained airports. By optimizing throughput, TMA helps to reduce arrival delays. The resulting uniformity of arrival flows can also lead to an increase in departure rates and a decrease in departure delays.

Inputs to the TMA system include real-time radar track data, flight plan data, and a three-dimensional grid of wind speeds and directions. TMA's trajectory models use this information, updated every 12 seconds, to compute routes and optimal schedules to the meter fixes for all arriving aircraft which have filed Instrument Flight Rules (IFR) flight plans, with consideration given to separation, airspace, and airport constraints. These

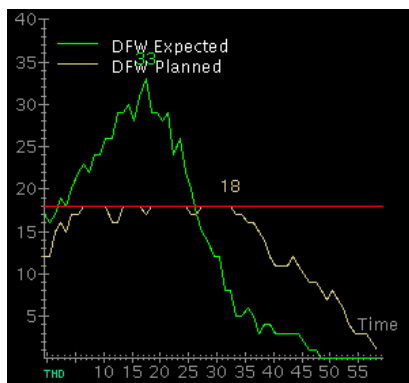
optimized schedules may then be displayed on controllers' radar displays, and used to ensure a smooth and efficient yet safe flow of aircraft to the terminal area.

Figures 5 and 6 present two of the displays available to traffic managers. Figure 5 illustrates the Timeline Graphical User Interface (TGUI) display. This display provides timelines for traffic arriving to specified meter fixes and runways within the next 30 minutes: the left side of each timeline portrays the estimated arrival times of aircraft if no action is taken, and the right side indicates the timing if TMA's schedule is adhered to. The current time is depicted at the bottom of each timeline, with future time in minutes indicated in the center of the bar. The load graph display (Figure 6) indicates the overall TRACON arrival rate for the original and TMA-adjusted flows, along with the TRACON's acceptance rate.

Once Traffic Management Unit (TMU) personnel decide that arriving traffic should be metered, TMA overlays a sequence list for a sector's arrivals on the controller's radar display. This list indicates the amount of delay that must be absorbed by each arrival to adhere to the TMA-computed schedule.



**Figure 5. TMA Timeline Graphical User Interface**



**Figure 6. TMA Load Graph**

#### **User Benefits**

Various studies have examined the operational benefits of TMA metering and traffic management capabilities. TMA metering has been found to increase arrival throughput and thereby reduce arrival delays. At some airports with shared runways, overall operations rates have increased (arrivals plus departures) during arrival peaks. When used by traffic managers as a planning tool, TMA has been found to reduce holding, reduce flight times, and reduce departure delay for airports controlled by the TMA Center.

A prototype of TMA was originally installed at the Ft. Worth Center for Dallas/Ft. Worth arrival traffic. Reference 6 reports that delays were reduced by 70 seconds per arriving aircraft during periods when demand exceeded capacity. Relatedly, the Terminal Radar Approach Control (TRACON) was able to increase the Airport Acceptance Rate (AAR) by 5 percent.

TMA was next installed at Minneapolis Center for Minneapolis/St. Paul arrivals. Operational analyses have reported an increase in rates at MSP of 4 and 5 operations per hour under visual and instrument conditions, respectively [4]. While initially there was no discernible change in AAR, once TMA displays were given to TRACON traffic managers the AAR was found to increase by 0.7 and 1.4 arrivals per hour during visual and instrument conditions, respectively [7]. Finally, an examination of flight distances for arriving flights showed a decrease of from 5 nmi (visual) to 9 nmi (instrument), and a redistribution of delay to higher, more fuel efficient altitudes [4].

TMA was next installed at Denver Center for Denver arrivals. While Denver has excess capacity at most times, there are times during poor weather where demand exceeds capacity and delays accrue. An assessment of TMA during these times found that the tool increased arrival rates by 1 (visual) to 2 (instrument) aircraft per hour [4].

Controllers at Los Angeles Center have only recently begun using TMA for metering arrivals. Initial studies focused on the use of the tool by traffic managers for planning and management. Reference 7 reported an increase in actual arrival rates of about 1.7 aircraft per hour, and an increase in AAR of about 1 aircraft per hour during instrument conditions. Reference 4 also reported a decrease in holding for arrivals, and a decrease in departure delay for airports controlled by the Center. A more recent analysis [3] has shown a further increase in arrival rates of five percent when time-based metering is employed, and a small increase in AAR.

The last three sites to receive TMA in the FFP1 program are Miami, Atlanta, and Oakland Centers, neither of which is currently using time-based metering. Nevertheless, some operational improvements have been observed as a result of improved situational awareness in the Traffic Management Units (TMUs). Traffic managers can use the tool to model Miles In Trail (MIT) restrictions before applying them, and to release aircraft from airports controlled by the Center bound for the TMA-primary airport. Reference 3 reports that Miami and Oakland have seen a reduction in average flight times and distances during peak periods, and also a reduction in the *variability* of flight distances. Miami and Oakland have also seen a reduction in departure delay for aircraft released by the Center. Atlanta has seen a reduction in holding for Atlanta arrivals. TMA benefits assessment results are summarized in Table 2.

**Table 2. Changes in Metrics Following TMA Introduction, FFP1 Sites**

Metric	Airport						
	DFW	MSP	DEN	LAX	ATL <sup>1</sup>	MIA <sup>1</sup>	SFO <sup>1</sup>
AAR	+5%	+0.7/hr vis, +1.4/hr inst		~ +1/hr			
Arrival Rate			+1/hr vis, +2/hr inst	~ +5%			
Ops. Rate		+4/hr vis, +5/hr inst					
Delay, all arrivals	-70 sec						
Delay, internal departures				-23% small airports, -10% LAS		-56%	-35%
Flight Distance		-5 nmi vis, -9 nmi inst				-6 nmi	-2.5 nmi
Flight time						-1.1 min East config, +.25 min West config	-.2 - -.3 min
Delay Distribution <sup>2</sup>		-2%					
Holding				-12% <sup>3</sup>	-24% <sup>4</sup>		

<sup>1</sup>Not currently using time-based metering capability

<sup>2</sup>Percentage of flight distance from 160 nmi to runway that is within the TRACON

<sup>3</sup>Total holding pattern circuits

<sup>4</sup>Total holding time

### ***Passive Final Approach Spacing Tool***

pFAST, the other CTAS tool fielded in FFP1, is used by controllers and air traffic managers to manage the flow of arrivals in the terminal airspace. pFAST computes a relative sequence for each arrival aircraft for each runway at an airport. Runway assignment is calculated in such a way as to minimize overall flight delay, with consideration given to aircraft type, speed, and trajectory. Runway advisories are displayed to the controller on the radar display. The controller may manually override both the relative sequence number and the runway advisory displayed by pFAST, and the system automatically adjusts to sequence number changes.

pFAST was fielded and evaluated at Dallas/Ft. Worth TRACON in 1999 and 2000. Various studies found increases in AAR and actual arrival rates when pFAST was used. Additionally, pFAST was found to lead to improvements in runway balancing [8]. Unfortunately, pFAST could not be adapted to all of the potential runway configurations at Dallas/Ft. Worth, and it could not be used when convective weather was in the TRACON vicinity. For these reasons it was not ultimately accepted by controllers, and its use was abandoned.

### ***Collaborative Decision Making***

#### **System Description**

CDM is a joint government/industry initiative aimed at improving air traffic management through

increased information exchange, procedural changes, tool development, and common situational awareness among the various parties in the aviation community. The initial focus of CDM, known as Ground Delay Program Enhancements (GDP-E), has operated throughout the NAS since September 1998. Under GDP-E, participating airlines send operational schedules and changes to schedules to the Air Traffic Control Systems Command Center (ATCSCC) on a continual basis. Through the use of Flight Schedule Monitor (FSM), the ATCSCC uses this information to monitor airport arrival demand and to conduct ground delay programs (GDPs). The airlines are also able to monitor arrival demands and model ground delay programs using FSM.

In addition to improving the execution of GDPs, CDM has been found to have application to other ATM problems, such as airspace congestion caused by heavy traffic or convective weather. CDM's Collaborative Routing function is intended to provide better information to airspace users about potential flow problems that are likely to require rerouting or other flow management actions. This allows users to prepare for possible effects on their operation in advance. The National Air Space Status Information function provides a mechanism to share critical safety and efficiency data with NAS users.

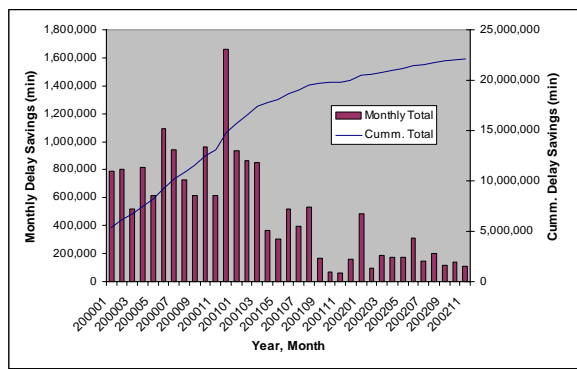
#### **User Benefits**

A traditional metric for GDP-Es has been the number of minutes of delay avoided through "compression." Compression is an inter-airline



resource allocation algorithm that advances take-off times of flights to fill arrival slots vacated by cancelled or delayed flights. This makes more efficient use of airport arrival resources by reducing the number of minutes of planned (i.e., FAA-assigned) ground delay. Compression, which was introduced by the GDP enhancements of CDM, has proven to provide substantial benefits to the user community [9].

Figure 7 shows the monthly and cumulative (since January 1998) ground delay reductions resulting from GDP-E compression through November 2002. Note that there has been a considerable reduction in delay savings since September 2001.



**Figure 7. GDP-E Compression Delay Savings**

### ***Surface Movement Advisor***

SMA disseminates terminal radar data to ramp controllers, giving them accurate touchdown time projections and increased awareness of traffic flow into the airport. This information helps airlines manage ground resources at the terminal more efficiently: gates, baggage handling, food services, refueling, and maintenance. Informed of aircraft identification and position in the terminal airspace, gate and ramp operators using SMA have enhanced ability to reduce taxi delays.

SMA became the first RTCA-recommended Free Flight program to be completed. SMA locations, activation dates, and principal users are presented in Table 3.

Feedback from airlines using SMA has been very positive; Northwest Airlines estimates that it is able to avoid three to five costly diversions weekly during periods of inclement weather [10].

**Table 3. SMA Deployment Sites and Dates**

<b>Airport</b>	<b>Date Deployed</b>	<b>Primary Airline</b>
Philadelphia	Dec. 1998	US Airways
Detroit	Dec. 1998	Northwest Airlines
Dallas/Ft. Worth	Nov. 1999	American Airlines
Chicago	Nov. 1999	United Airlines
Newark	Nov. 1999	Continental Airlines
Teterboro	Nov. 1999	General Aviation

### **Free Flight Phase 2**

Based on the results of the field evaluations of FFP1 tools described above, positive feedback from NAS users and Air Traffic Control (ATC) facilities, along with additional cost/benefit analyses, the RTCA recommended that the FAA continue with the development and deployment of the FFP1 automation tools.

FFP2 is the next step in the evolution towards Free Flight, which the RTCA broadly defines as the removal of restrictions on users' flight trajectories. FFP2 will geographically expand URET and TMA between 2003 and 2006. FFP2 will also develop and field enhancements to CDM, and introduce a new airborne data link system, Controller Pilot Data Link Communications (CPDLC).

In addition to the above-mentioned capabilities, the FFP2 program will facilitate several research and development activities being conducted by the National Aeronautics and Space Administration (NASA) and MITRE. The FFP2 core research activities are:

- Surface Management System (SMS)
- Direct-To (D2) Tool
- Traffic Management Advisor – Multi-Center (TMA-MC)
- Problem Analysis, Reporting, and Ranking (PARR)
- Equitable Allocation of Limited Resources (EALR).

These capabilities will be demonstrated at operational facilities when they mature, then evaluated to determine if full-scale development and operational deployment should proceed.

The deployment plans and status of the FFP2 programs are described below.

### ***URET and TMA***

Following the success of URET in FFP1, URET will be deployed to the remaining 13 Centers as part of FFP2. The current deployment schedule is presented in Table 4.

**Table 4. FFP2 URET Deployment Schedule**

Center	IDU
Jacksonville (ZJX)	July '03
Minneapolis (ZMP)	Aug. '03
Ft. Worth (ZFW)	Sept. '03
Denver (ZDV)	Sept. '03
Salt Lake (ZLC)	Nov. '03
Albuquerque (ZAB)	Dec. '03
Boston (ZBW)	Feb. '04
New York (ZNY)	March '04
Cleveland (ZOA)	May '04
Houston (ZHU)	June '04
Los Angeles (ZLA)	July '04
Miami (ZMA)	Aug. '04
Seattle (ZSE)	Sept. '04

TMA will also be geographically expanded in FFP2. Indianapolis, Houston, Memphis, and Kansas City Centers are to receive TMA for Cincinnati, Houston Intercontinental, Memphis, and St. Louis arrivals, respectively. The TMA deployment schedule is presented in Table 5.

**Table 5. FFP2 TMA Deployment Schedule**

Center/Airport	IDU Date
ZHU/IAH	Aug. '03
ZID/CVG	Nov. '05
ZME/MEM	May '06
ZKC/STL	Dec. '06

## CDM

CDM initiatives in FFP2 are organized into the five following areas:

- Enhanced Data Exchange
- Arrival and Departure Management
- Congestion Management
- System Impact assessment
- Performance Assessment.

There are many initiatives under each of these program areas. A few of the most promising are described briefly below.

### GDP Enhancements

A number of enhancements are being made to FSM and ETMS to better execute GDPs. GDPs which include departure airports based on the distance from the target airport (distance-based), which consider the load on different arrival fixes for an airport (fix-based), and which consider multiple airports within a TRACON or in close proximity (multi-airport) are envisioned. Additionally, a capability for airlines to trade arrival slots with each other is being developed (Slot Credit Substitution [SCS]).

## Re-Route Tools

Several tools are being developed to help traffic managers and airlines more efficiently re-route traffic around weather or other problems. The Route Management Tool (RMT) allows users to view the centralized Coded Departure Routes database and related tables from the National Flight Data Center. The Re-Route Advisory Tool (RAT) can identify flights affected by a re-route advisory and transmit this information to airlines in machine-readable form.

### Flow-Constrained Area Tools

The Collaborative Routing Coordination Tools (CRCT), being developed by MITRE, helps traffic managers identify sectors that will be overloaded because of severe weather or excessive demand, and assess the impact of re-routing flights on all sectors in the Center. CRCT functionality is gradually being added to ETMS.

### Analytical Tools

Several tools are being developed to aid with the analysis of NAS operations. Real-time Flight Schedule Analyzer (FSA) can help managers better understand a GDP while it is in progress. Using the Post Operations Evaluation Tool (POET) analysts can readily access, visualize, and analyze up to 37 days of flight plan and track data nation wide.

## CPDLC

The FAA is developing a data link system to enhance air-ground communications. Controller-Pilot Data Link Communications (CPDLC) provides an additional communications medium to complement the voice channels used by controllers and pilots for the exchange of air traffic clearances and information. This capability will help to relieve congested voice channels that limit ATC effectiveness and the potential capacity of airspace. CPDLC may also ultimately aid in the implementation of more advanced automation features.

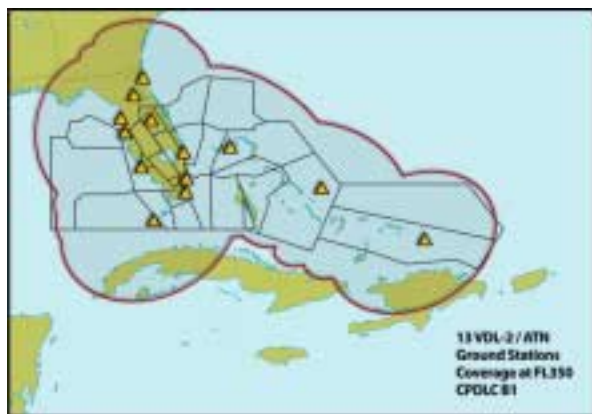
The Free Flight program is implementing CPDLC in a phased approach that maintains consistency with ICAO standards. The first iteration, CPDLC Build I, became operational at Miami Center in October 2002. CPDLC Build I implements the following four messages:

- Initial contact
- Transfer of communications
- Altimeter setting
- Menu text.



Free Flight Program Office analyses indicate that these four messages make up about 57 percent of voice channel occupancy in en route airspace.<sup>3</sup>

Figure 8 illustrates the coverage area for CPDLC Build I at Flight Level 350. This coverage is achieved with an Aeronautical Telecommunications Network (ATN) using 13 VHF Digital Link Mode 2 (VDLM2) ground stations. At the time of writing (December 2002), 16 American Airlines aircraft were equipped and operational with CPDLC-compatible avionics. Continental, Federal Express, Delta, and the U.S. Air Force are expected to be CPDLC equipped in 2003.



**Figure 8. Initial CPDLC Coverage**

The Free Flight Program Office is now working with Computer Sciences Corp. to develop a robust and nationally deployable version of CPDLC. While plans for the national deployment have yet to be definitized or approved, the current schedule calls for expansion of the Build I capability to ZJX, ZHU, and ZFW in late 2005-early 2006. Build IA, which incorporates an additional 5 messages, would be deployed nationally (beginning with the four Build I Centers) between August 2007 and December 2011.

## **FFP2 Research Programs**

### **Surface Management System**

SMS is a decision support tool that is intended to help controllers, traffic managers, and air carriers collaboratively manage the movement of aircraft on the surface at busy airports, thereby increasing capacity and efficiency and improving flexibility.

<sup>3</sup> CPDLC addresses only the en route portion of ATC data link services. The terminal and tower environments will be addressed separately.

SMS will provide tower controllers with accurate predictions of departure queue lengths, delays, and future demand for each runway or other constrained resource, as well as advisories to help manage surface movements and departure operations. SMS is being developed by the NASA Ames Research Center and partner contractors.

### **Direct-To (D2) Tool**

D2 is a decision support tool for en route radar controllers that has the potential to improve both controller and airspace efficiency, thereby facilitating flight time savings for airspace users. D2 provides advisories for traffic conflicts and wind-favorable direct routings, and includes an interactive trial planning function that allows controllers to quickly visualize, evaluate, and input route and altitude changes. D2's user interface, encompassing direct route advisories, conflict advisories, and the trial planner, is fully integrated into the radar controller's traffic situation display. D2 route and conflict advisories are displayed in the flight data block and in optional lists on the R-side traffic situation display.

D2 is based on the NASA Center/TRACON Automation System (CTAS) trajectory algorithms and software.

### **TMA – Multi-Center (TMA-MC)**

TMA-MC, currently under development at the NASA Ames Research Center, is intended to assist traffic managers and controllers in Centers and TRACONs with efficiently managing arrival traffic flows through complex airspace. TMA-MC will provide the same functions as TMA, but will work for airports near Center boundaries (such as Philadelphia International), where data from multiple Centers will need to be fused and metering occur in multiple facilities. TMA-MC will allow personnel at these different facilities to collaborate on optimizing arrival flows to an airport near the Center boundaries.

### **Problem Analysis, Reporting, and Ranking**

Initial PARR, which will assist en route controllers in dealing with aircraft-to-aircraft and aircraft-to-airspace problems, has two components: Assisted Trial Planning (ATRP) and the Assisted Resolution (ART) tool.

ATRP is an enhancement to the altitude, direct-to-fix, and speed menus that are currently available in URET. These menus allow a controller to check whether a change of altitude would be free of conflicts, assess whether a more direct route could be offered, or check whether a speed change would resolve an existing conflict. With URET, this process is manual, i.e., the controller selects an altitude to try, submits the request, and is notified of the conflict

status of the resultant trial plan. With ATRP, the conflict statuses of multiple possibilities are returned simultaneously. For example, for an altitude request, the conflict status for a band of altitudes, above and below the currently assigned altitude, is presented. In addition, a trial plan for each altitude has already been built, and the controller can easily select and implement the trial plan for the preferred option.

ART will similarly assist controllers in dealing with aircraft-to-aircraft and aircraft-to-airspace problems, but will perform this function automatically. This capability should help controllers find solutions to problems where the density or complexity of en route traffic might make it difficult to develop a trial plan that resolves the problem without creating others. As with ATRP, ART will be a closely integrated enhancement to URET, and will utilize the same URET user interface. A User Team is currently working with MITRE engineers to further develop the ART concept.

## Conclusions

FFP1 has been largely successful at its objective of fielding new ATM automation systems that can improve the capacity and efficiency of the NAS. Quantitative performance assessments, as well as qualitative assessments from controllers and airspace users, have confirmed the operational utility of these systems. FFP2 will continue the consensus-building, rapid development, early fielding, and operational evaluation techniques pioneered in FFP1. While not all FFP2 initiatives may prove successful, the program should yield systems which provide measurable benefits to NAS users.

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## Key Words

ATM | automation tools | benefits assessment | CDM | CPDLC | CRCT | CTAS | D2 | FFP1 | FFP2 | Free Flight | GDP | PARR | pFAST | POET | RAT | RMT | SCS | SMA | SMS | TMA | TMA-MC | URET

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